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A MICROWAVE POWER SOURCE FOR LABORATORY USE

W. WYSLOUZIL AND F. VACHON

DECEMBER 1982

Canada

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ABSTRACT

A simple laboratory microwave power source utilizing a domestic microwave oven magnetron operating at 2450 MHz is described. A separate filament transformer and SCR phase control are used to provide "instant on" operation and adjustable output power from 0 to 800 W. The unit operates from a standard 115 V, 15 A outlet.

RÉSUMÉ

On décrit une source de puissance micro-onde simple pour laboratoire, utilisant un magnétron de four micro-onde courant fonctionnant à 2450 MHz. Un transformateur de filament distinct et une commande de phase à thyristor assurent la mise en marche "instantanée" et procurent une plage de puissance de sortie s'étendant de 0 à 800 W. L'appareil se branche sur une prise ordinaire de 115 V, 15 A.

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INTRODUCTION

Commercially available microwave power packs are relatively expensive and often exceed the requirements for simple laboratory investigations.

The domestic microwave oven magnetron offers an attractive alternative. It is mass produced and consequently inexpensive while exhibiting reliable operation under the most adverse conditions. In addition, some of the associated components such as transformers, rectifiers, and capacitors are also readily available at reasonable cost.

With that in mind, a simple power pack capable of generating microwave power at 2450 MHz, with power output adjustable from 0 to about 800 W was developed and is described below.

GENERAL DESCRIPTION

The power pack (see Figs. 1 and 2) is contained in two packages, one comprising the magnetron with waveguide coupler, the other containing the power supply and operating controls. The two units are connected with a cable approximately 1.5 m in length. This construction was used to facilitate use of the unit in experimental setups and to allow positioning of the operating controls in a convenient location.

Operating controls consist of a main power on-off switch, a "standby" switch for instant on/off operation, and a power level control knob. Provision is also made to allow remote on-off operation. A meter is incorporated to monitor the anode current for an approximate indication of output power, and a test point is provided to allow monitoring of the anode current waveform with an oscilloscope.

The entire unit weighs only 15.5 kg and can easily be carried by one person.

DESCRIPTION OF CIRCUITRY

A circuit diagram of the SCR phase controlled power supply is shown in Fig. 3.

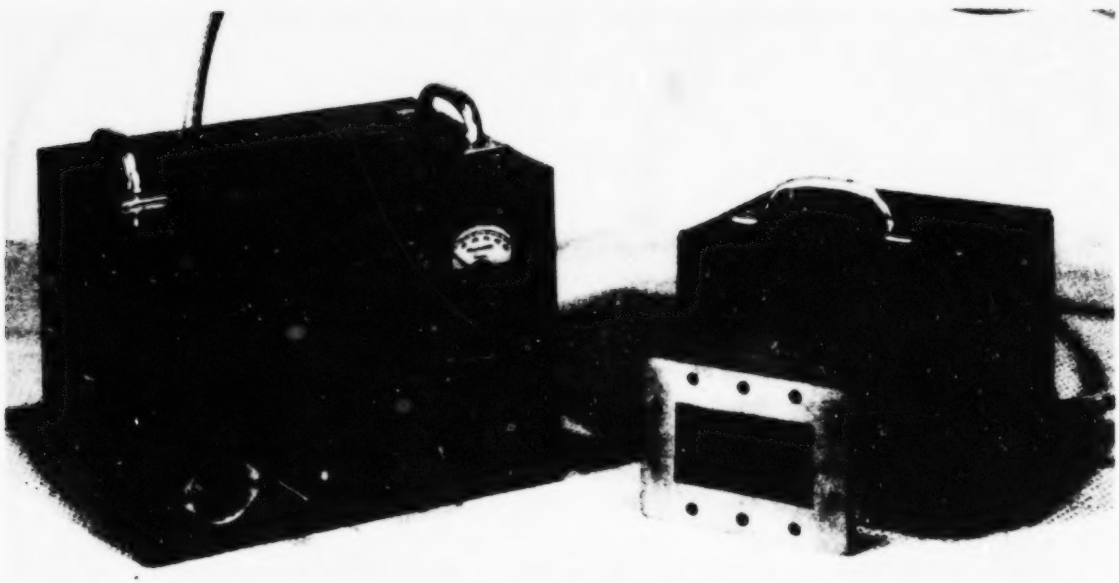


Figure 1 800 W, 2450 MHz power pack

Filament Supply

Operation of the magnetron requires a filament or heater voltage of 3.15 V at 14 A, and a dc anode voltage of up to 4 kV. To allow smooth control of the microwave power level and to permit "instant on" operation, the filament voltage is provided by a separate transformer T4. Since the filament warm-up time is only 3 s, and since domestic oven magnetrons are designed to survive simultaneous application of filament and anode voltage, no time delay circuit was incorporated. It is important, however, to ensure that adequate voltage is applied to the filament to prevent moding and premature tube failure. Therefore the voltage drop in the interconnecting cable must be taken into account when designing the filament transformer. T4 as shown is appropriate for the 1.5 m lengths of #15 stranded wire used.

Anode Supply

The high voltage is generated by means of T3, a commercially available transformer intended for use in microwave ovens, and a half-wave doubler circuit comprising a high voltage capacitor and rectifier which are also standard oven components. To compensate for small losses in the

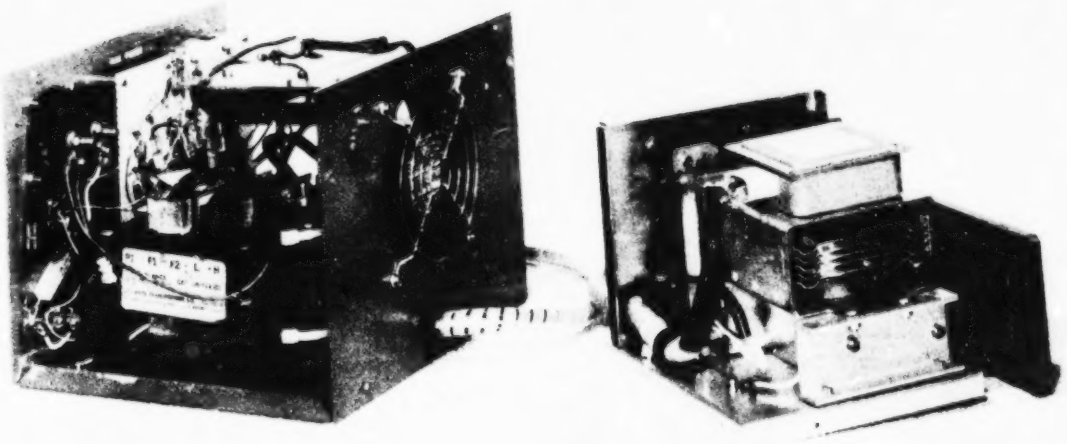


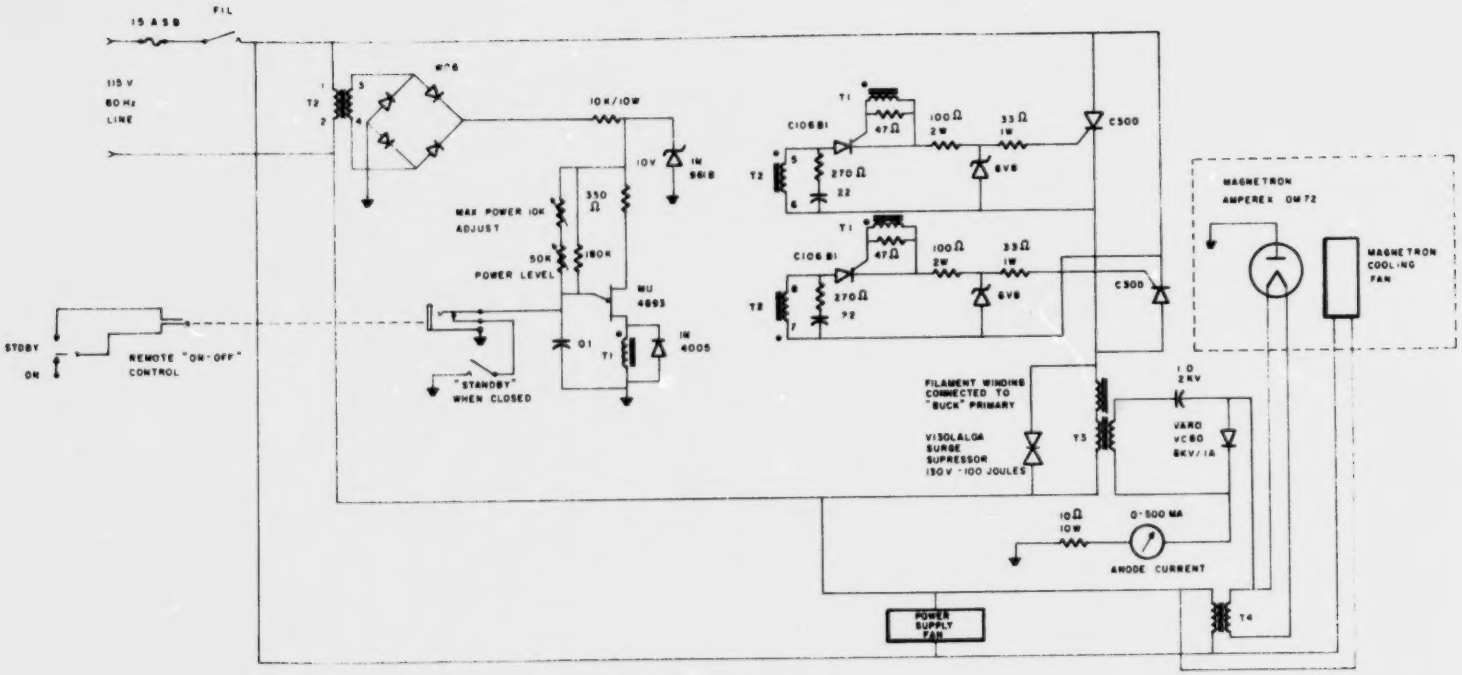
Figure 2 Power pack with cover removed

control SCRs, the unused filament winding which is incorporated in T3 is connected to "buck" the primary winding, resulting in slightly increased secondary voltage.

The primary voltage of T3 is varied by means of an SCR phase control circuit using two C30D SCRs and a control circuit suitable for inductive loads (1). A surge suppressor across the primary of T3 serves to protect the SCRs from high voltage transients. The anode circuit is completed to ground through a 0-500 mA meter and a 10 Ω resistor. The meter gives an indication of magnetron power level and the voltage across the 10 Ω resistor is available at a front panel test point to allow monitoring of the anode current waveform.

Phase Control Circuit

The unijunction transistor (MU4893) is connected across the ac supply line by means of the W06 bridge rectifier, permitting it to trigger on both halves of the ac cycle. The time constant of the "Max. Power Adjust" and "Power Level" potentiometers in conjunction with the 0.1 μF capacitor determines the delay angle at which the unijunction transistor delivers its first pulse to the primary of pulse transformer T2 during each half cycle. The pulses are coupled directly to the gates of the two



NOTES

1) ALL RESISTORS 1/4W UNLESS NOTED OTHERWISE
2) ALL CAPACITORS IN μF
3) C 30 D'S MOUNTED ON HEAT SINK
4) T1 SPRAGUE 11721Q1 1:1 PULSE X FORMER
   T2 SIGNAL LP 40-150
   T3 ADVANCE 09-111-26
   T4 PRIMARY HAMMOND 498B1 PRIMARY COIL
   SECONDARY 16 T # 12 INSULATED FOR 5 KV
   CORE 3.75" X 3 1/8" X 1 1/4" THICK
5) INTERCONNECTING CABLE
   1 Sm OF 14 GTO-15, 15,000V
   CANADA WIRE "NEON SIGN STRAND"
6) COOLING FANS-BOXER MODEL W5210TFL-1000

Figure 3 Circuit diagram of power supply

C106 B1 "pilot" SCRs. Whichever of these SCRs has positive anode voltage during that specific half-cycle triggers and delivers voltage to its respective main SCR, firing it in turn. The low voltage ac supply for the "pilot" SCRs is derived from transformer T2. The zener diodes and associated resistors serve to prevent excessive power dissipation in the gates of the main SCRs.

Standby and Remote Control

The "Standby" switch simply disables the SCR trigger circuit by grounding the emitter of the unijunction transistor. Remote control is achieved in the same manner. Plugging in the remote control cord disables the "Standby" switch.

WAVEGUIDE COUPLER

The magnetron is designed to operate into WR340 waveguide. Dimensions of the recommended coupler section are given in the magnetron data sheet (see Appendix A).

REFERENCES

1. G.E. SCR Manual. Fifth Edition. pp. 265-266.

APPENDIX A

Amperex
A NORTH AMERICAN PHILIPS COMPANY

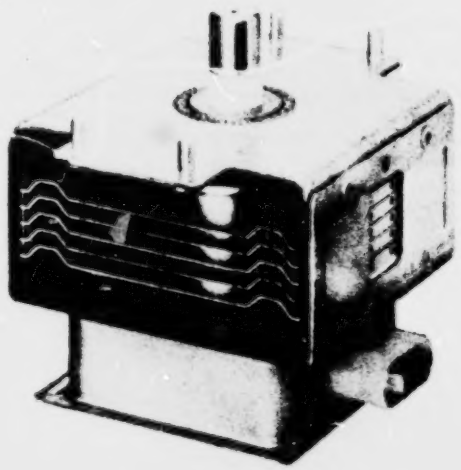
AMPEREX ELECTRONIC INDUSTRIES INC. / SMITHFIELD DIVISION

GEORGE WASHINGTON HIGHWAY / SMITHFIELD / RHODE ISLAND 02917 / TEL: (401) 232-0500

C. W. MAGNETRON TYPE OM72

ADVANCE DATA

The Amperex OM72 is a fixed frequency (2450 MHz) continuous wave cooking magnetron intended for use in domestic ovens with typical oven power of 600–750 Watts.



This modern U.S. manufactured magnetron features all ceramic-metal construction, light weight and small volume, high efficiency, stable operation under the most severe oven conditions, long life expectancy with practically constant performance, and a packaged magnet system with very low magnetic stray fields.

Quality control and data are based on the practical application of the tube such as the use of a high peak current half-wave doubler power supply without any preheating, combined with power control by means of interval opeation.

Special attention has been paid to reduce interference radiation from the input and output of the tube including the generation of higher harmonics.

A measuring probe is available which enables a simple cold measuring procedure to match the tube to all kinds of applicators.

The Rieke diagram, based on impedance measurements with the measuring probe, allows a direct plotting of cold measuring results into this diagram.

The small size of the wave guide coupler makes it particularly suitable for applications in ovens.

The tube is a direct replacement for a number of obsolete foreign made and current production types.

GENERAL CHARACTERISTICS

ELECTRICAL

Frequency *(matched load)*	2450 ± 10 MHz
Filament	directly heated thoriated tungsten filament
Filament voltage at average anode current of 300 mA	3.15 ± 10% V
Filament current	14 A
Cold filament resistance	30 mΩ
Filament preheating time	0 Seconds
Anode potential	ground
Filament potential	negative high potential

MECHANICAL

Dimensions	See outline drawing. Width - Length - Height* 103 × 127 × 87 mm 4.06 × 5.00 × 3.43 inches
Terminal connection	See outline drawing
Mounting position	Any
R. F. Coupler	See drawing
Magnetic System	Ferrite magnet-packaged
Cooling	Forced air
Weight *(approx.)*	1.1 kg 2.4 lbs

*Antenna height excluded.

Rev. JULY 1977

ABSOLUTE MAXIMUM RATINGS

	Min.	Max.
Filament voltage at average anode current of 300 mA	2.85	3.50 Volt
Heating time	0	Seconds
Average anode current		350 mA DC
Peak anode current		1.2 A
Average anode input (*1)		1400 W
Allowable load v.s.w.r.	¼	4 (*2)
Anode-cathode voltage		+12 KV
Anode core temperature (*3)		180° C
Storage temperature	-30°	+60° C

*1) Anode input defined as peak anode voltage ⊗ average anode current.

*2) In oven applications with stirrers load VSWR up to 10 may be allowed.

*3) See outline drawing for measuring point.

TYPICAL OPERATION

With anode voltage from a single-phase, half-wave doubler power supply.

Frequency	2450 MHz
Filament voltage	3.15 V
Peak anode voltage	4.0 KV
Average anode current	300 mA
Peak anode current	1000 mA
Tube output power *(Matched load)*	830W
Usefull power output *(typical oven)*	750W
Cooling, rate of airflow	0.8 m^3/min. 29 C.F.M.
Static pressure drop *(approx.)*	6 mm H_20 0.24 inch H_20

MEASURING PROBE FOR C.W. MAGNETRON OM72

A prototype measuring probe has been made according to the present state of the tube development.

The probe was coupled to a waveguide launching section having a distance of 21.0 mm from the heart of the antenna to the backwall in the waveguide.

In this configuration, the probe was matched with the aid of a quarter wavelength transformer in the coaxial line.

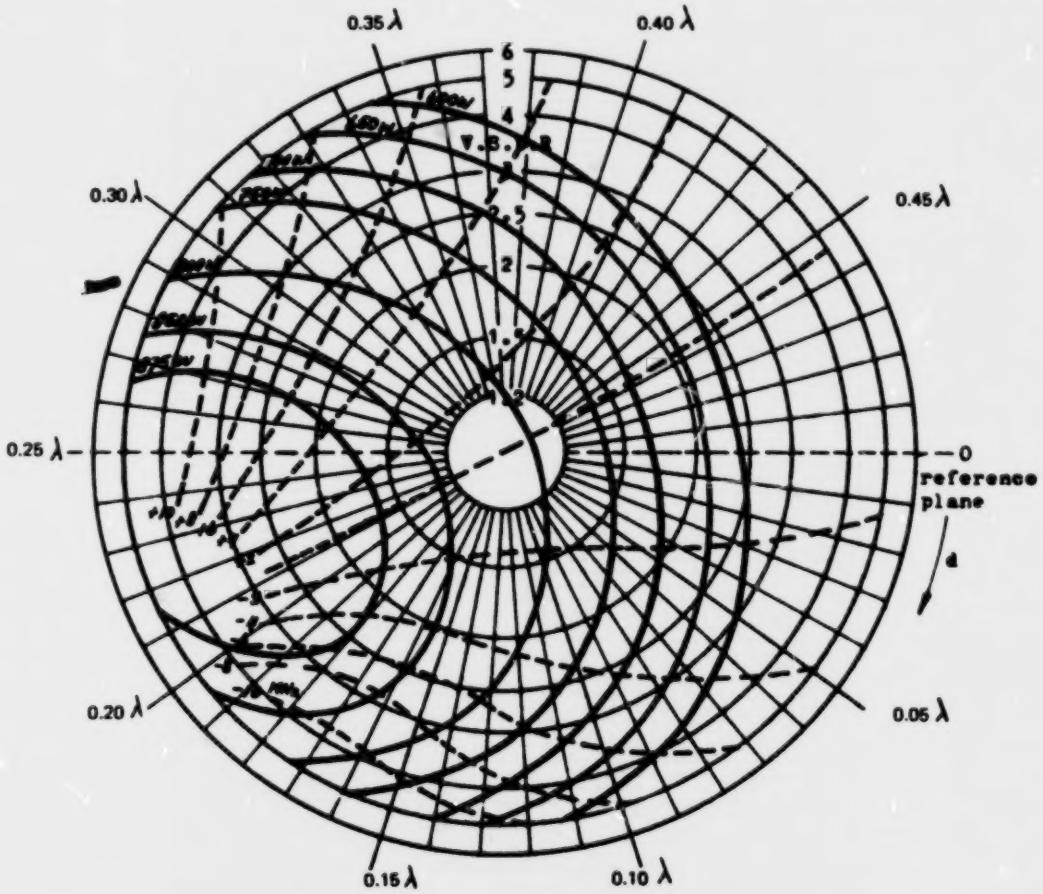
The VSWR of the probe was measured on the coaxial N-type input system. The waveguide was terminated with a load having a VSWR of ≈1.02.

The VSWR readings are taken on 1 probe and represent typical data.

Frequency (MHz)	VSWR
2430	1.06
2450	1.03
2470	1.09

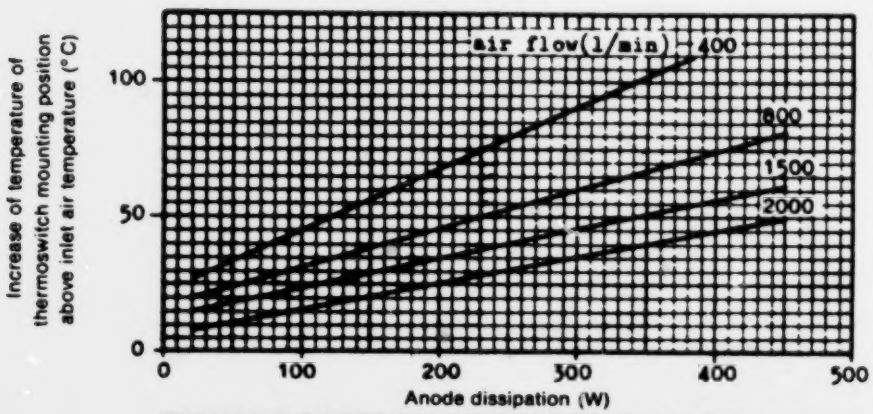
The electrical length between the plane through the heart of the antenna and the reference plane on the coaxial input of the probe has been adjusted to a number of half wavelengths.

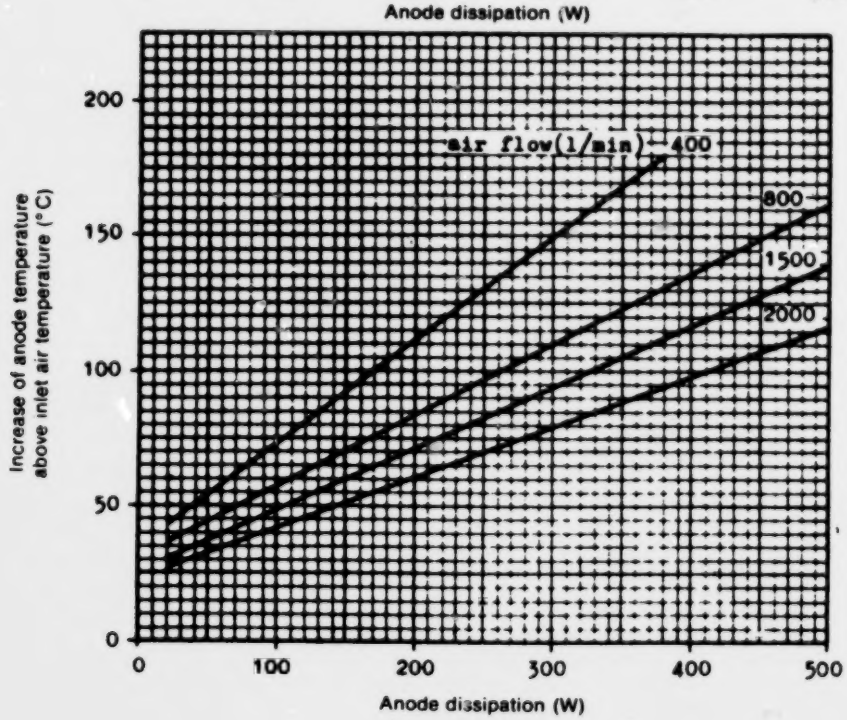
RIEKE DIAGRAM OM72



Anode supply : half wave doubler L–C type
Filament voltage : 3.15 V
Average anode current : 300 mA
Peak anode voltage (matched load) 4.0 kV
Frequency (matched load) 2450 MHz
d= distance V.S.W.R. minimum from reference plane of the measuring probe towards load.

COOLING CHARACTERISTICS

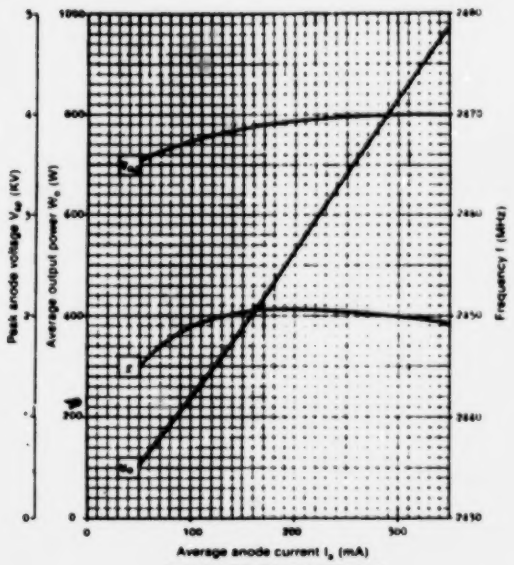




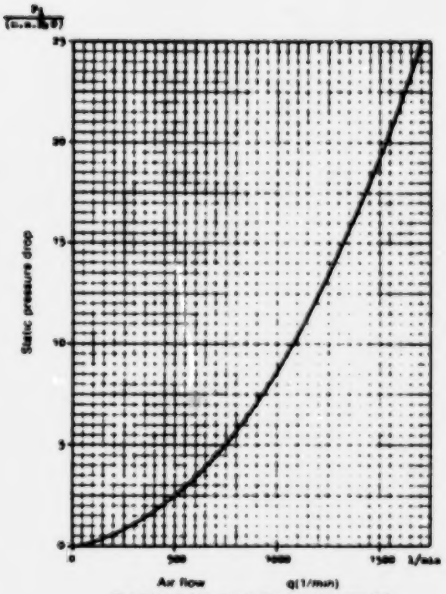
Anode dissipation = (peak anode voltage) × (average anode current) − (output power)

Operating conditions:
Anode supply, single phase half wave doubler power supply.

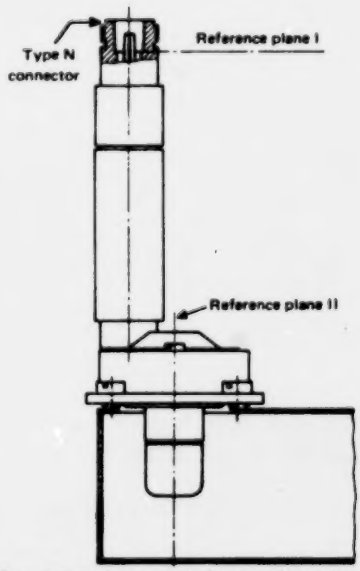
Peak current= 3.5 average anode current.
Filament voltage 3.15 V
Load VSWR <1.1



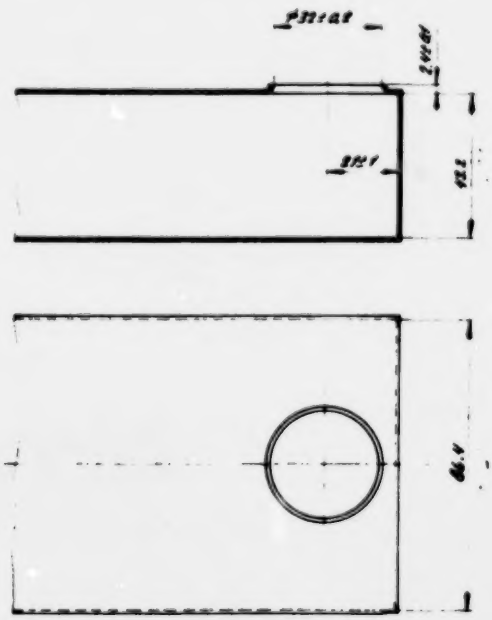
PERFORMANCE CHART



RADIATOR CHARACTERISTICS



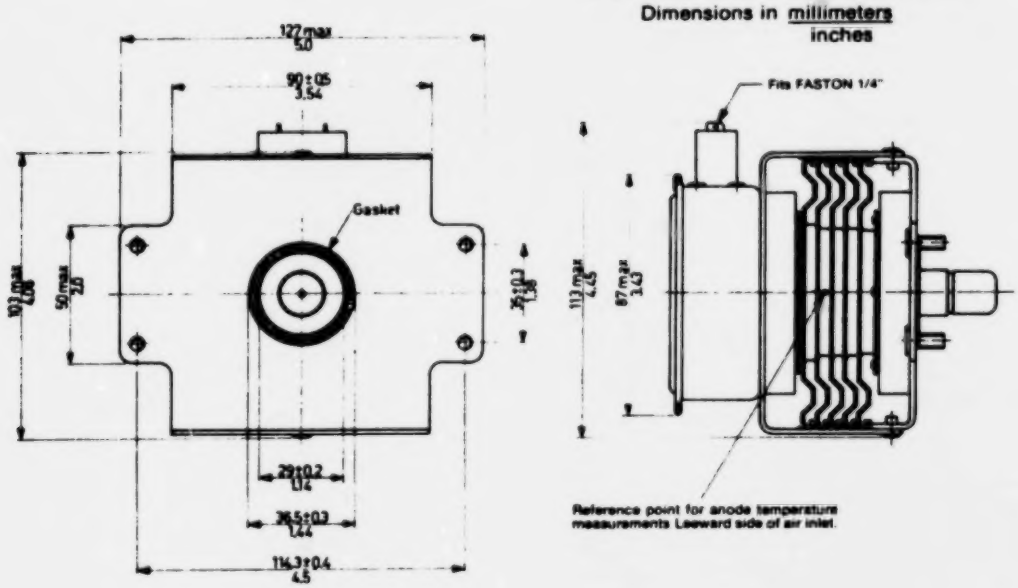
Measuring probe connected to coupler section R26

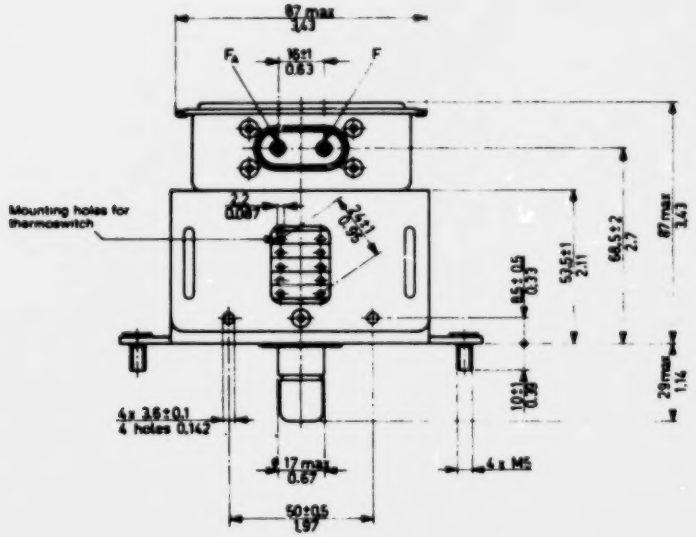


COUPLER SECTION R26

OUTLINE DRAWING - OM72

Dimensions in millimeters
inches





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APPENDIX B
POWER SUPPLY SPECIFICATIONS

Mechanical

Dimensions	- Power Supply Unit	- 27 cm × 19 cm × 24 cm
	- Magnetron Assembly	- 16 cm × 18 cm × 14 cm
Weight	- Power Supply Unit	- 11.3 kg
	- Magnetron Assembly	- 4.1 kg
Length of Interconnecting Cable		- 1.5 m

Electrical

Input Power		- 115 V, 60 Hz, 15 A max.
Output	- Frequency	- 2450 ± 25 MHz
	- Power	- 0-800 W (matched load)
	- Anode Current	- 290 ma at 800 W
	- Allowable Load VSWR	- 4 continuous
		- 10 intermittent

POOR

QUALITY

ORIGINAL